(2) Serviceability Limit State

The serviceability limit state involves normal use or durability of the structure. In general, the design involves mainly problems related to cracking. The ranges of reinforced concrete behavior related to the ultimate and serviceability limit states are generally divided by the point of the yielding of a member (Fig. 1.3).

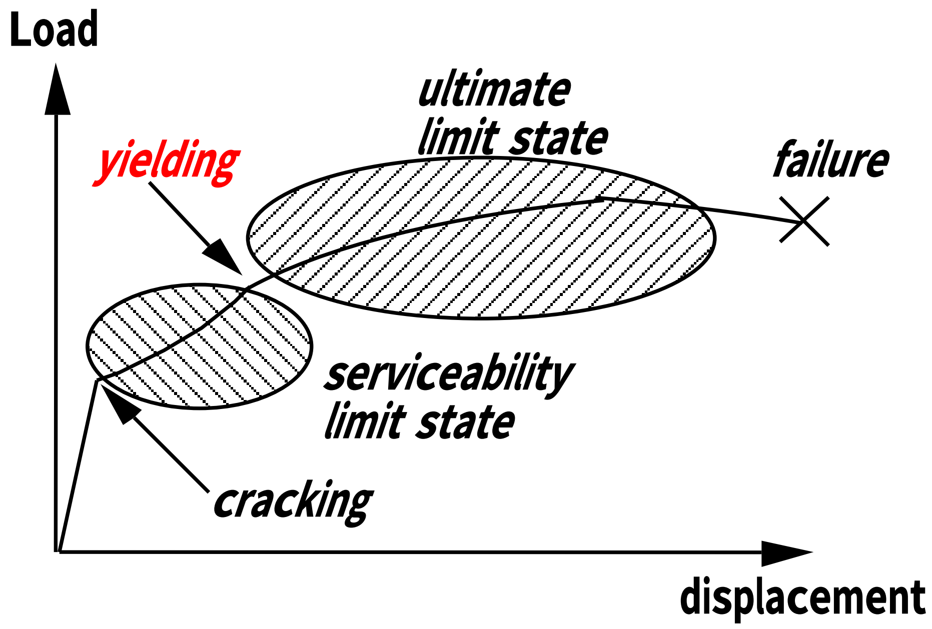

Fig. 1.3 Applicable ranges for serviceability and ultimate limit states

Table 1.2 Examples of the serviceability limit state

Serviceability limit state for	Conditions
Cracking	Impairment of appearance, durability, or water and air tightness of the structure.
Deformation	Excessive deformation which is not suitable for normal use.
Displacement	Excessive displacement which does not impair stability and equilibrium, but is not suitable for normal use.
Local damage	Local damage which prevents normal use of the structure.
Vibration	Excessive vibration which is not suitable for normal use, or produces uneasiness.
Source of vibration	Vibration which propagates to surrounding structures through foundation and produces discomfort.

(3) Fatigue Limit State

The fatigue limit state is associated with the fatigue failure of the structure or structural members due to load repetition. The fatigue limit state can be considered to be one of ultimate limit states, because the structure fails at the fatigue limit state. However, since the fatigue failure under repeat loading involves a variable strength not a static strength as in the ultimate limit state, the fatigue limit state is treated separately in JSCE specification.

Design procedures for the limit state design are depicted in Fig. 1.4.

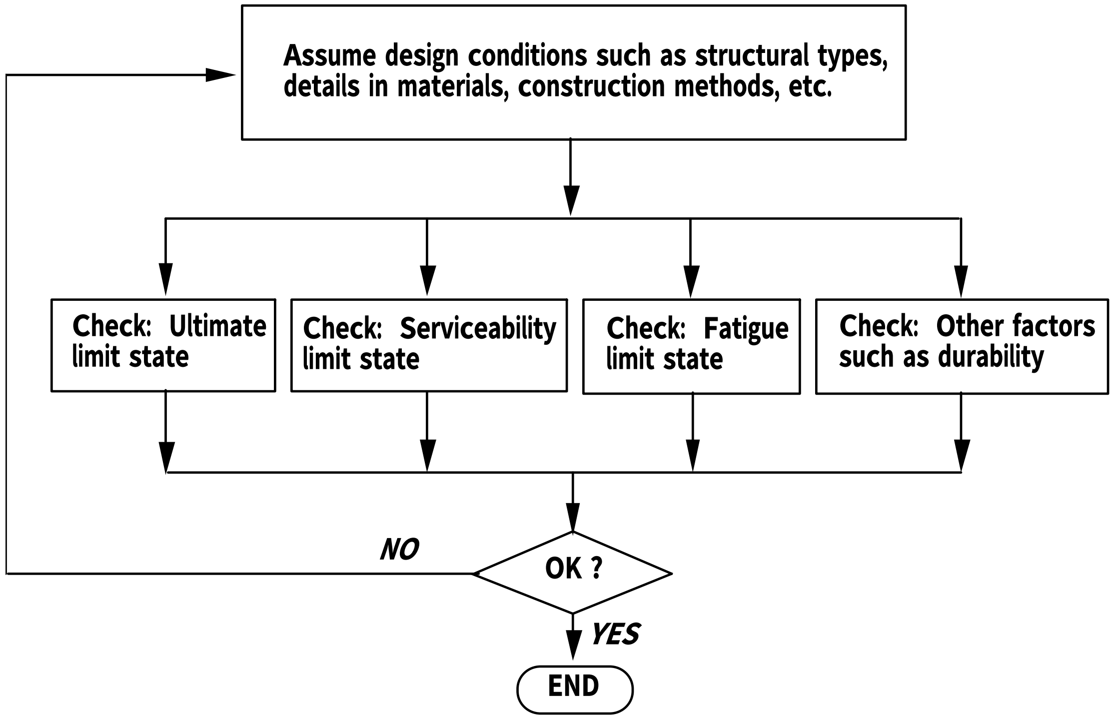

Fig. 1.4 Design procedures for limit state design

1.3.2 Characteristic values of material strengths and loads, and modification factors

The characteristic value and specified (nominal) value are used to determine the design values of material strengths and loads. The characteristic value is a statistical value. In other word, the values of material strengths or loads are analyzed by statistical approach in order to determine the characteristic value. The specified (nominal) value is determined by other methods than that of the characteristic value. The relation between the specified and characteristic values is;

$$f_k = \rho f_n \qquad (1.3)$$

where,

f_k **: characteristic value**

f_n **: specified value (nominal value)**

ρ **: modification factor**

(1) Characteristic Values of Material Strengths

Characteristic value for material strength f_k is determined in order to ensure that most of the tested values ensues it, in consideration of scattering of the tested values, and can be expressed as;

$$f_k = f_m (1 - k \delta) \qquad (1.4)$$

where,

f_m : the average of tested values

δ : coefficient of variation of tested values

k : coefficient determined by probability to have tested values less than the characteristic value and distribution shape of tested values (Fig. 1.5)

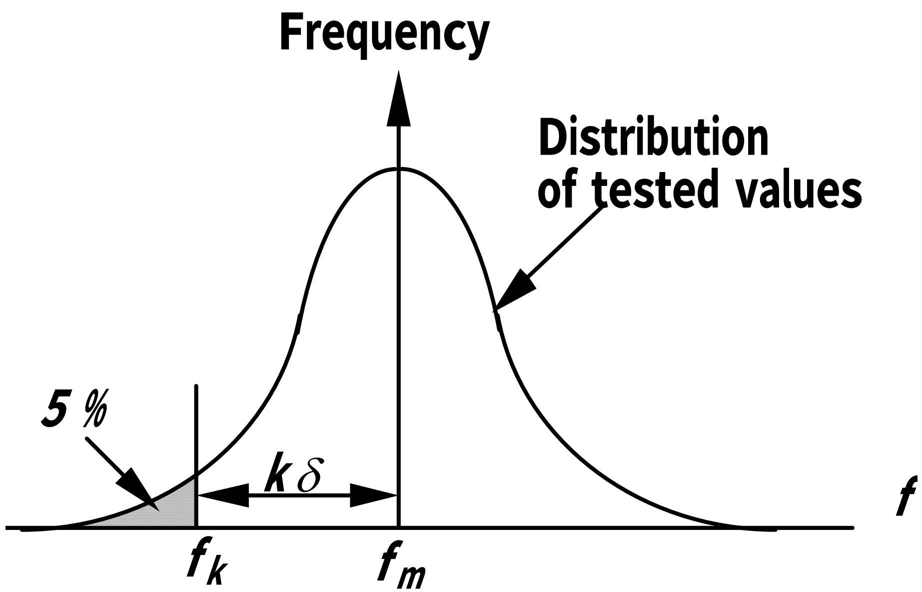

Fig.1.5 Characteristic value for material strength

When the normal distribution is assumed, and the probability of tested values which fall below the characteristic value is less than 5 %, k becomes 1.64.